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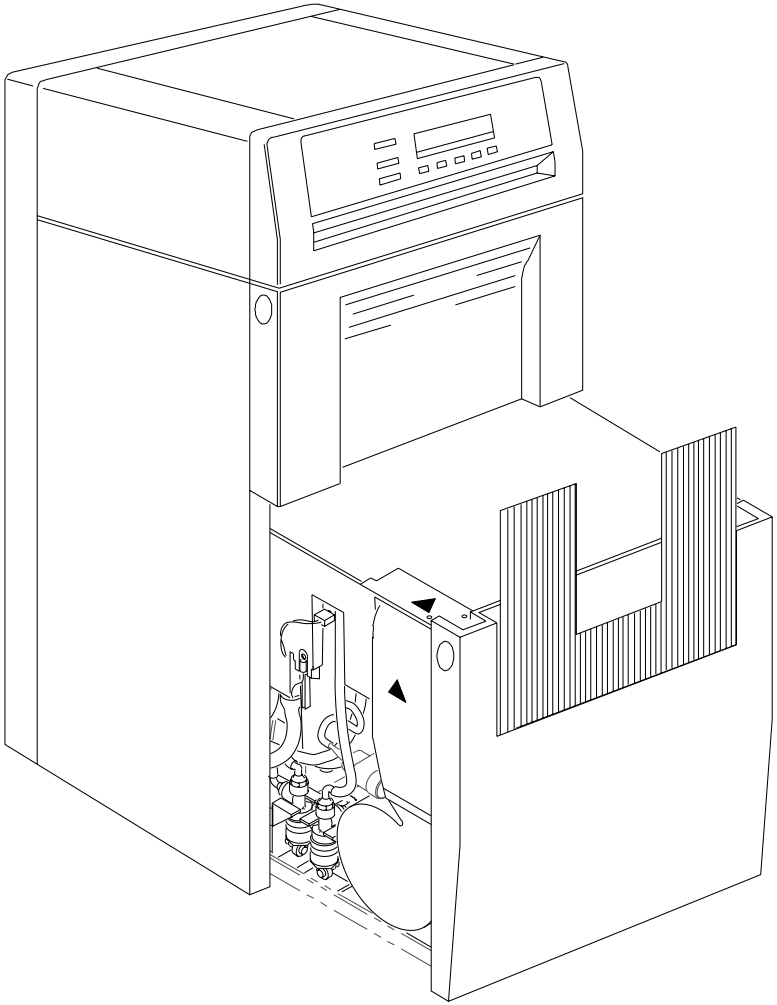
HEALTH IMAGING

THEORY GUIDE
for the
Kodak X-Omat 3000 RA INTEGRATED PROCESSOR
in a *Kodak X-Omat* MULTILOADER 300 PLUS



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Section 1: Introduction

Product Description

The Kodak X-Omat 3000 RA PROCESSOR is a general purpose radiographic PROCESSOR and uses a conventional transport drive to accomodate sheet radiographic film. The PROCESSOR provides 4 film cycles that operate at 4 default transport speeds:

- K/RA
- Rapid
- Standard
- Extended

All cycles, except for the K/RA cycle, use standard RP chemicals and film; however, the K/RA cycle requires the use of RA chemicals and film. Each of the 4 cycles has default parameters for

- transport speed
- developer and fixer replenishment volumes
- developer, fixer and dryer temperatures

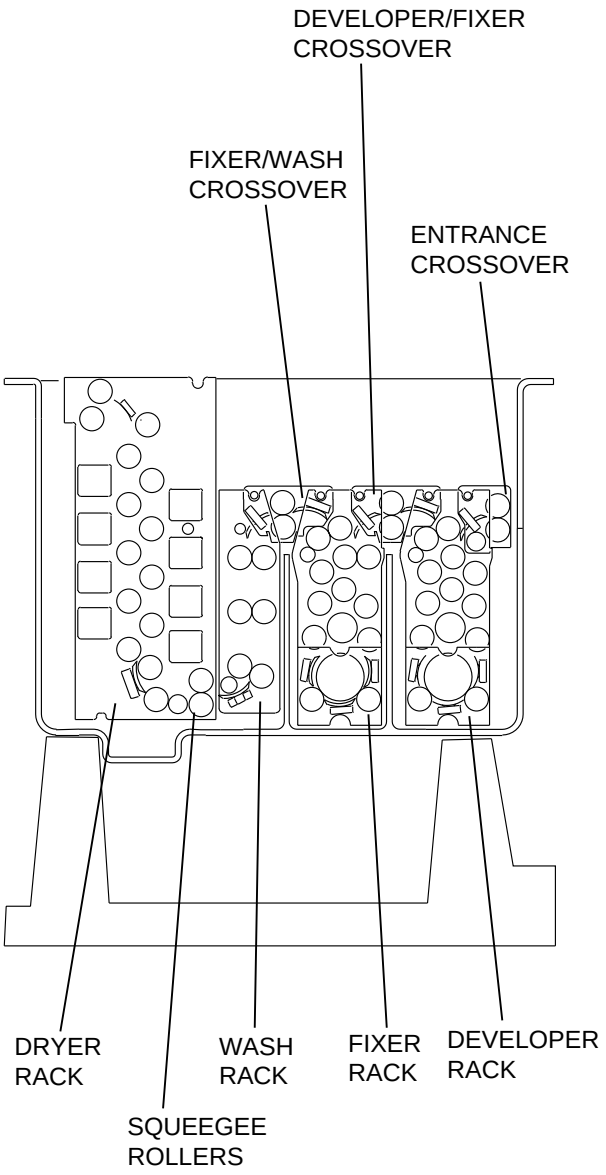
These default parameters are stored in memory and can be modified by the user. A BATTERY supplies uninterrupted power to memory. These parameters do not change when the operator de-energizes the PROCESSOR.

The 3000 RA PROCESSOR is available in two versions:

- stand-alone Processor
- integrated Processor that is incorporated into the *Kodak X-Omat* Multiloader 300 PLUS.

This publication addresses the integrated version only. For the Theory Guide for the stand-alone Processor, see publication Part No. 5B6332.

Processor Operation



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The Multiloader 300 PLUS feeds patient film into the Processor. The film is then transported through the machine by a network of motor-driven rollers known as the film transport assembly.

The film travels through 2 chemical tanks and a wash system, where the following solutions are applied to the film:

1. **Developer**

   This solution converts the invisible latent image on the film to a visible image.

2. **Fixer**

   This solution stops the continued development of the visible image by removing unused silver halide crystals from the film. The RP fixer also increases the permanency of the visible image by hardening the emulsion. The RA fixer, however, does not include a hardener because the film has a pre-hardened emulsion.

3. **Water**

   The water removes all excess fixer from the film, which prepares the film for drying. This ensures a permanent image on the film.

Upon exiting the wash tank, the film is transported through a dryer. In the dryer, a blower circulates warm air across the surface of the film. The dry, processed film then exits the Processor.

The 500 circuit board monitors and controls Processor functions. The role of this circuit board is described in more detail elsewhere in this publication.

While the film moves through the various chemical tanks, the Processor is controlling several other functions. These functions create optimum processing conditions in the tanks:

- **Maintaining the Correct Temperature of the Developer and Fixer**
- This function is accomplished by controlling the developer heater and the fixer heater. The heaters are located inside the developer and fixer thermowells. The solution thermistors sense the temperature of the developer and fixer in the thermowells.
- **Cooling the Developer**
- This function is accomplished by energizing 2 solenoids; the wash water solenoid, which is on the Multiloader bulkhead, and the developer cooling solenoid. When the wash water solenoid opens, water is supplied to the wash rack. The water collects around a heat exchanger at the bottom of the wash tank. When the developer cooling solenoid energizes, developer flows through the heat exchanger. The cooler water surrounding the heat exchanger effectively cools the developer solution.
- **Replenishing the Developer and Fixer Tanks**

- This function is accomplished by activating the developer and fixer replenishment pumps each time 0.15 m^2 (238 $in.^2$) of film are measured by the Multiloader 300 PLUS. The amount of solution added to the tanks during each replenishment cycle is specified by the operator. External replenisher tanks or an automixer is connected to the Processor to supply the developer and fixer solutions.
- **Maintaining the Correct Temperature in the Dryer**
- This function is accomplished by energizing a blower motor and an air heater to circulate warm air across the surface of the film. A dryer thermistor senses the temperature of the air in the dryer. The Processor also includes an automatic, resettable dryer overtemperature thermostat that senses abnormal temperatures and shuts off the heater. Additional protection is provided by a thermal cutoff.
- **Transporting the Film through the Processor**
- This function is accomplished by energizing the main drive motor when film is detected by the Multiloader 300 PLUS. The drive motor drives the rollers that transport the film from the entrance rollers, through the Processor, and to the exit.
- The drive motor controller provides a feedback signal, which allows the processor control software to compensate for varying torque loads and maintain a constant transport speed.
- **Diagnostic Features**
- The Processor also includes special software that allows the Processor to interface with an IBM compatible portable computer. This feature increases diagnostic capabilities and provides quick updating of processor software. With the portable computer, new software can be downloaded directly into the Processor, rather than installing new memory chips.

Section 2: System Initialization

When power is applied, the software checks the setup and operation of the Processor. The system initializes variables, I/O ports, and serial communications ports.

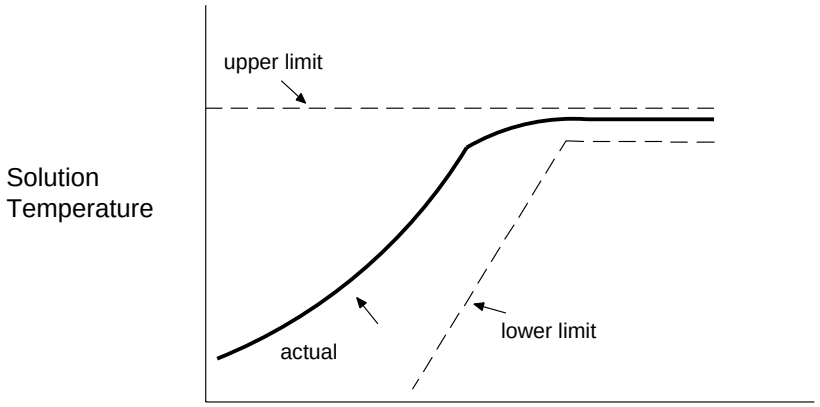
The initialization begins with a self-check to verify correct operation of the Processor. The self-check verifies the:

- Operation of the internal RAM and external RAM
- Checksum of the main program EEPROM
- Operation of external input/output devices If the self-check locates an error, the Processor will display a fatal E001 error. If the self-check is successful, the initialization continues and the Processor:
  - energizes the wash water solenoid, allowing water to flow into the Processor
  - energizes the dryer blower and air heater
  - checks the developer and fixer solution levels If the levels are not correct, the replenishment cycle activates and the tanks are filled. If the level does not reach the correct level within 4 minutes, a tank fill error occurs.
  - energizes the recirculation pump after the solutions reach their operating levels This circulates the developer and fixer solutions through the thermowells where they are heated, if necessary. A ready condition will be sent to the ML300 PLUS when the solutions reach their operating temperatures. If the temperature increases too slowly, however, an error condition occurs.
- The microprocessor uses algorithms and controls to monitor the temperature of the solutions. The temperatures should increase at a normal rate within 15 - 20 minutes. The chart below illustrates the relationship between temperature and time.

If the initialization sequence is completed successfully, the Processor sends a “Ready” message to the Multiloader 300 PLUS.

Note

The status LED DS7, located on the 500 circuit board, flashes on and off at $1\,/_2$ -second intervals when the software is operating correctly.



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Section 3: Film Transport

Film Detection

Now that the Processor is ready, the operator can process film by loading a film cassette into the Multiloader 300 PLUS. As the cassette enters, the Multiloader determines the size of the cassette, which indicates the length and width of the film. This information is sent to the Processor for replenishment area calculation.

When the Processor enters the operating mode, the following occurs:

- The main drive activates.
- The wash water solenoid energizes, providing water to the wash rack after an amount of time that allows the lead edge of the film to start exiting the fixer rack. This is done to conserve water.
- The dryer blower and heater energize.

Drive System

Control of the DC DRIVE MOTOR

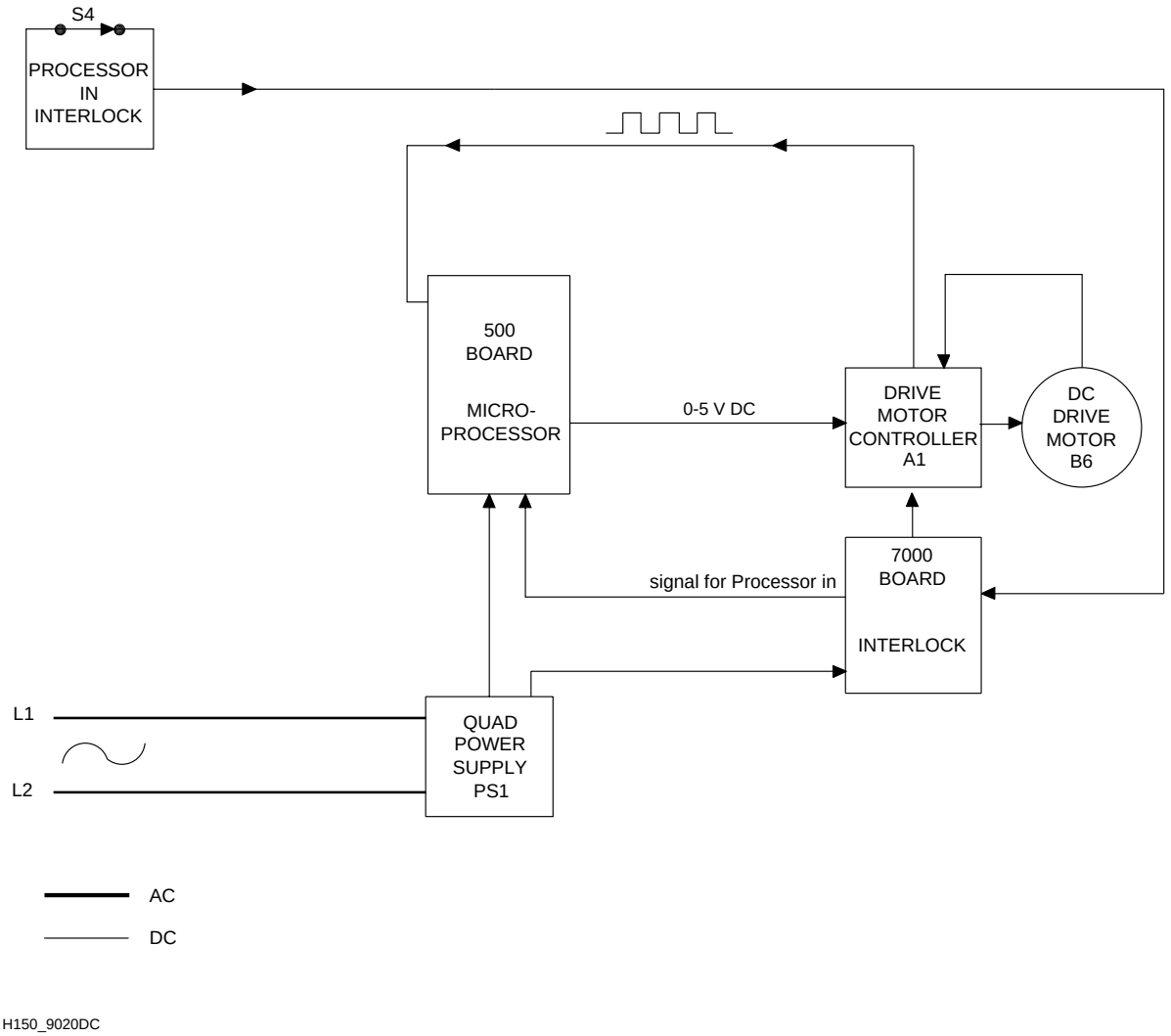


Table 1 Typical* Control Voltages of the 4 Processing Cycles

Cycle	V DC
Extended	1.0
Standard	1.9
Rapid	2.6
K/RA	3.4

Note

* The control voltages can vary from one PROCESSOR to another PROCESSOR.

Actuating the Transport Drive

After receiving the feed signal from the ML300 PLUS, the microprocessor actuates the transport drive. The MICROPROCCESOR will not actuate the transport drive if any of the following conditions occur:

- If the processor is pulled out of the ML300 PLUS
  - the S4 PROCESSOR IN SWITCH opens
  - RELAYS K1 and K2 on the 7000 board deenergize and turn off the 24 V DC power to the DRIVE MOTOR CONTROLLER
- If the operator has selected either “Go To Setup” or “Select Cycle” from the main menu.

Speed Control

The QUAD POWER SUPPLY PS1 supplies +24 V DC to the drive motor controlleR through the K1 and K2 relays on the 7000 board. In addition, the 7000 board regulates +24 V DC to +5 V and supplies this +5V to the motor controller board. A brushless, variable-speed DC DRIVE MOTOR drives the film transport, which operates at a different speed for each of the 4 processing cycles. (See the table at the bottom of the previous page). A DIGITAL to ANALOG (D/A) CONVERTER on the 500 BOARD converts the digital value of the required speed to one of 4 analog values between 0 and 5 V DC. The table indicates the typical control voltages.

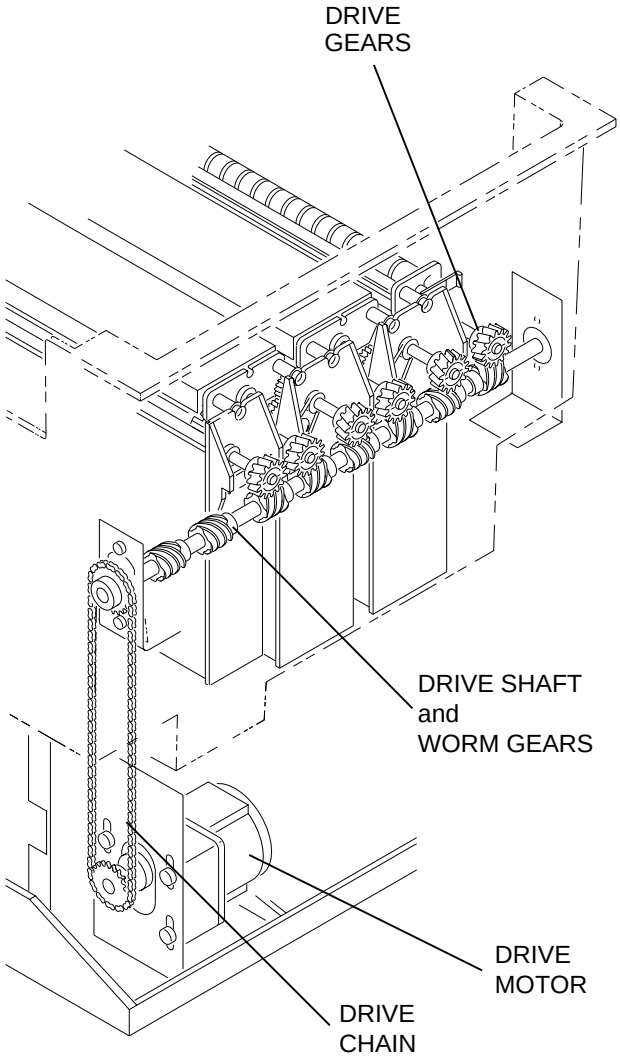
The 500 board applies the required control voltage to the drive motor controller:

- The DC DRIVE MOTOR contains a pulse GENERATOR (not indicated in the diagram) that produces a feedback signal of 12 pulses per revolution. This feedback signal indicates the speed of the DC DRIVE MOTOR.
- The DRIVE MOTOR CONTROLLER receives the feedback signal and sends it to the MICROPROCESSOR.
- If necessary, the MICROPROCESSOR adjusts the speed of the DC DRIVE MOTOR by varying the analog voltage applied to the DRIVE MOTOR CONTROLLER.

Transport Errors

- **Inoperative Transport (E004):** If the feedback indicates a pulse count less than a threshold value, the MICROPROCESSOR determines that the transport speed is zero. The DISPLAY PANEL displays the fatal error message “Inoperative Transport”.
- **Loss of Transport Speed Control (E041):** If the speed of the transport drive assembly varies by 7.62 cm/minute (3 inches/min) above or below the setpoint speed for 10 seconds, the DISPLAY PANEL displays the non-fatal error message “Loss of Transport Speed Control.”

Figure 1 **Drive Components**



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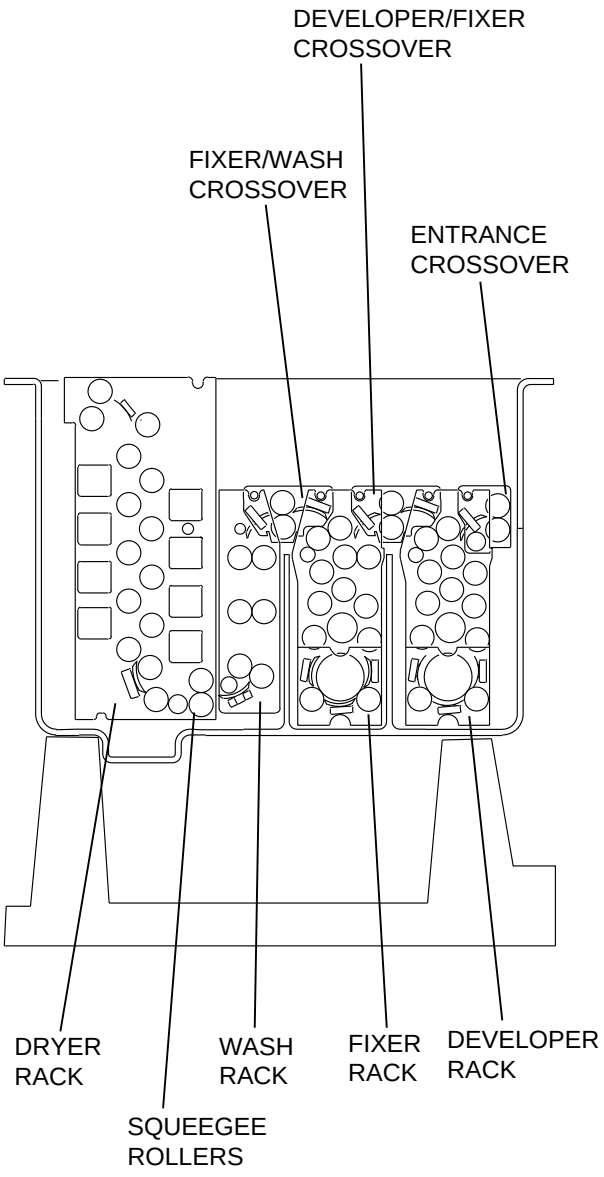
The above diagram indicates components of the transport drive. When the drive motor energizes, the drive shaft and worm gears rotate, transferring drive to the drive gears, rotating the transport rollers of each racK to move the film through the PROCESSOR.

Film Transport Assembly



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Now that drive is supplied to the film transport assembly, the film is transported through the ENTRANCE CROSSOVER to the developer rack, the fixer rack, the wash rack, and the dryer rack. The racks consist of a series of rollers driven by chains and gears. Although the developer and fixer racks are similar, they cannot be interchanged. This is especially important to prevent chemical residues from contaminating other solutions.

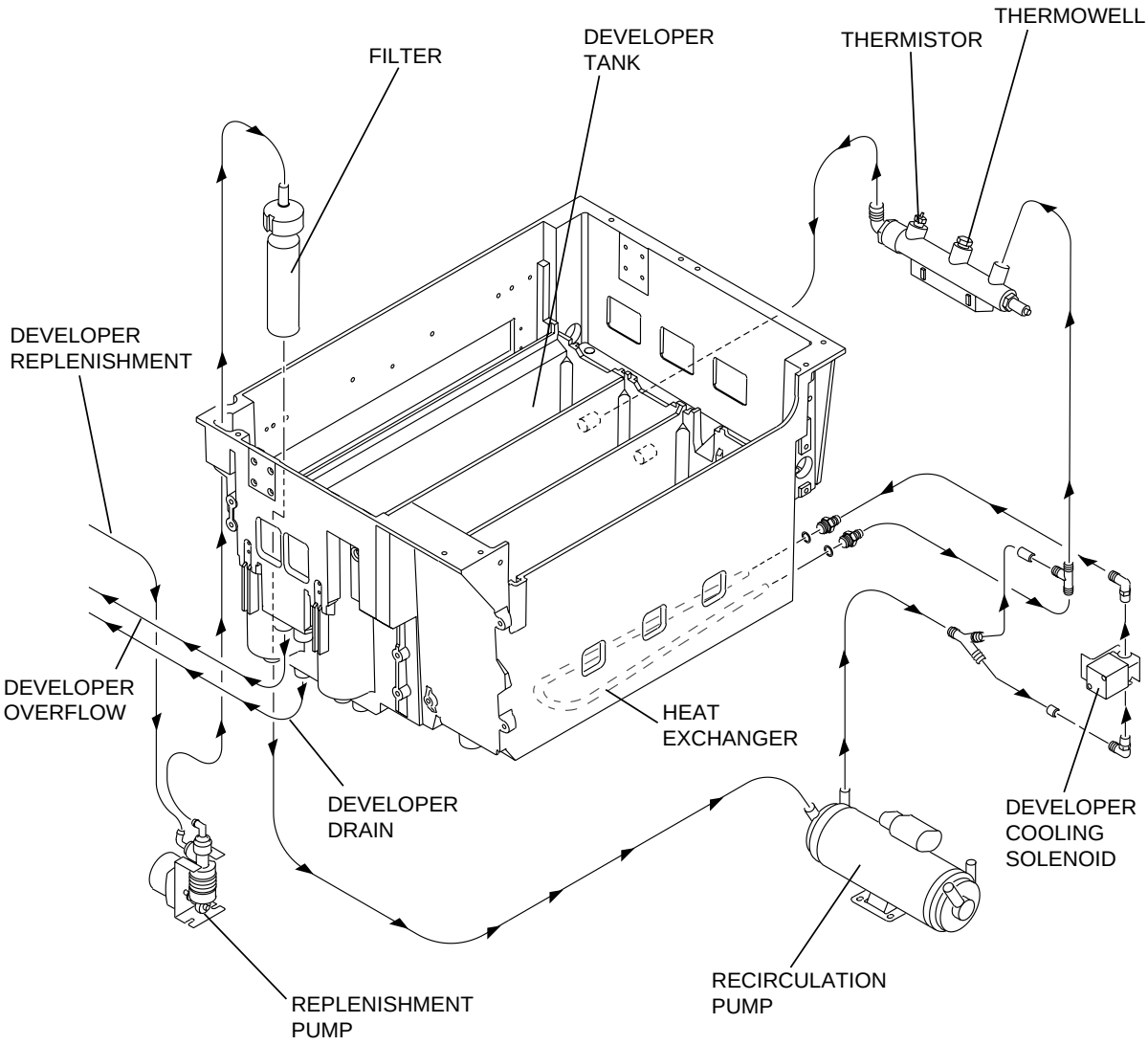
Between each rack is a crossover assembly that transports the film between racks. The pressure applied by the rollers also removes any remaining solutions from the film surface before it enters the next rack.

When the film leaves the wash rack, it passes into the dryer rack. Here, squeegee rollers remove remaining droplets of water across the film surface, to encourage fast, uniform drying. The rollers in the dryer rack then move the film through the dryer rack and out of the Processor into the receiving tray.

Section 4: Processing

Developer

Recirculation



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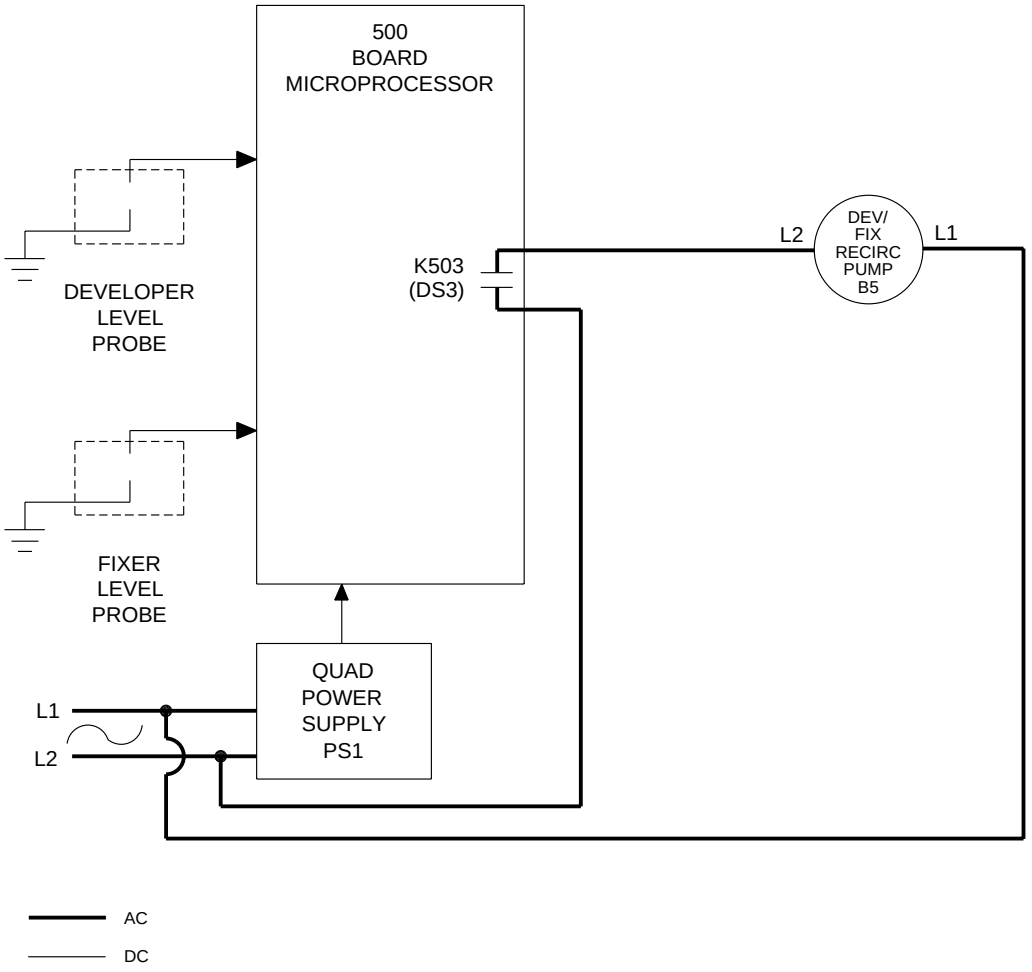
The transport drive moves the film into the developer tank, which contains 8.53 L (2.25 gal) of developer solution, a mixture of developer chemical and water. The developer solution converts the invisible latent image on the film to a visible image. An external tank of replenishment or an automixer supplies developer to the DEVELOPER TANK. For more information about replenishment, see Section 5: Replenishment, Page 25.

Recirculation takes place only when the tanks for both the developer and fixer are full. A LEVEL PROBE in each tank monitors the level of solution.The PROCESSOR contains a DUAL-HEADED RECIRCULATION PUMP, consisting of a MOTOR that is magnetically coupled to the DEVELOPER RECIRCULATION PUMP and the FIXER RECIRCULATION PUMP. The MOTOR drives both PUMPS. The developer recirculation pump circulates the developer solution continuously through a thermowell, filter, and DEVELOPER TANK. When the developer requires cooling, then the developer circulates through the HEAT EXCHANGER.

Figure 2 **Control Circuit for Recirculation of Developer and Fixer**



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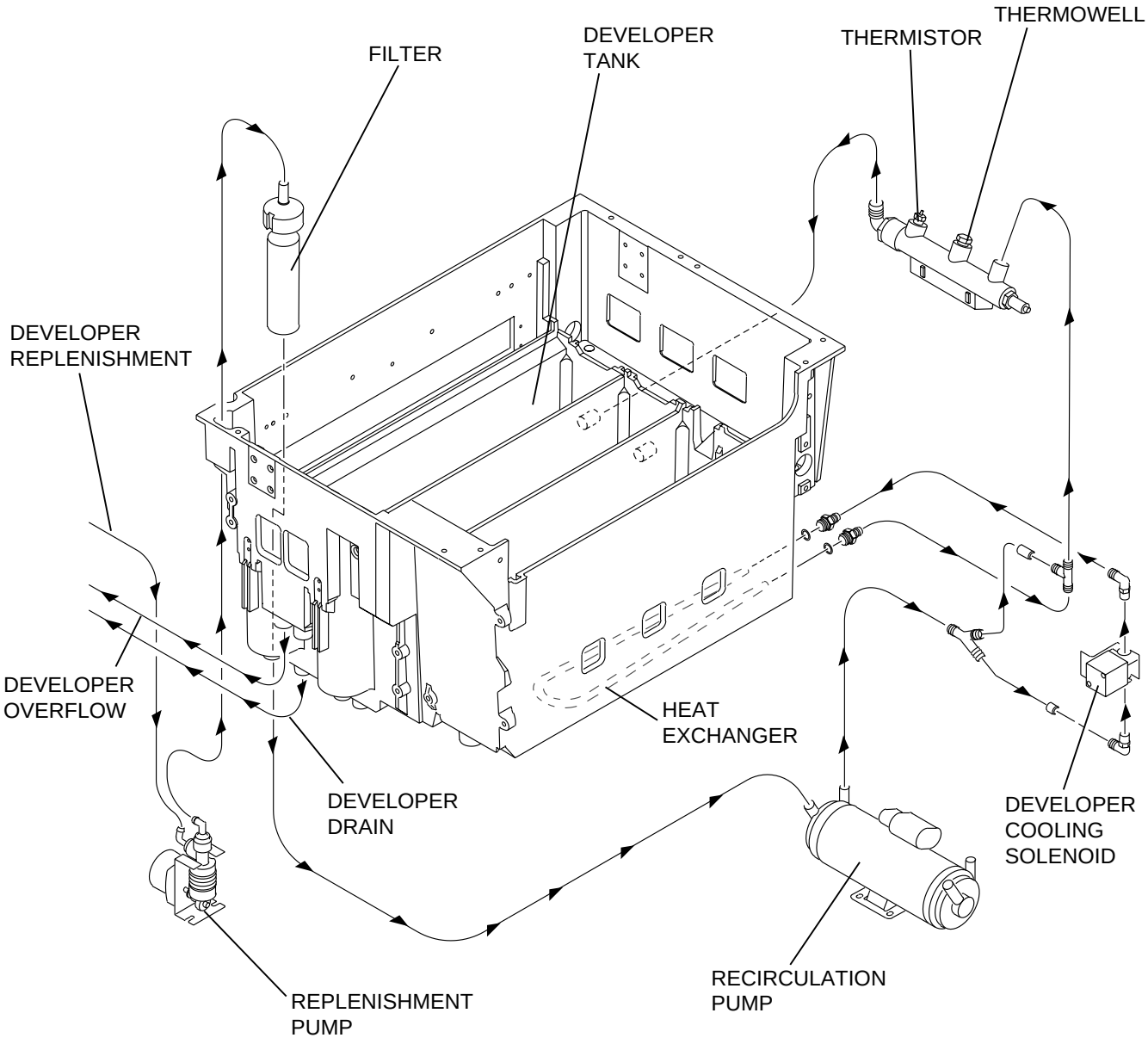
The control circuits for recirculation of the developer and the fixer are the same. Each of the TANKS for the developer and the fixer contains a separate LEVEL PROBE. A correct level of solution in the TANK immerses the LEVEL PROBE, providing a path to ground. The microprocessor monitors the resistance of this path:

- If the level PROBE is not immersed in solution for 10 consecutive readings, approximately 5 seconds, the MICROPROCESSOR detects a high resistance and determines that the level is low.
- If the level PROBE is immersed in solution, the MICROPROCESSOR detects a low resistance and determines that the solution is at the correct operating level.

When the MICROPROCESSOR detects that **both** solution levels are correct, it closes the contacts of the electromechanical relay K503, energizing the recirculation pump. The LED DS3 illuminates. If the solution does not reach the correct level within 4 minutes, the MICROPROCESSOR sends a “Tank-fill error” (EO32-development tank and EO33-fixer tank) to the ML300 PLUS.

Developer Temperature



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Developer Heating

The MICROPROCESSOR maintains the temperature of the developer at plus or minus 0.3C (0.5F) for optimum processing of the film. The setpoint temperature depends on the cycle. The microprocessor continuously monitors the resistance of the thermistor in the thermowell. This resistance changes inversely with the temperature of the developer. For more information about the thermistor, see Section 8: Thermistors and Temperature Measuring, Page 30.

The thermowell contains a heater that energizes at different duty cycles to maintain the temperature. The microprocessor uses an algorithm to control the duty cycle:

X=Setpoint temperature in F minus solution temperature in F	Duty Cycle of the Developer HEATER
X 0.5	100%
0.3 £ X < 0.5	60%
0.1 £ X < 0.3	40%

X=Setpoint temperature in F minus solution temperature in F	Duty Cycle of the Developer HEATER
0 < X < 0.1	20%
X £ 0	0%

Therefore, the HEATER

- operates continuously when the solution temperature is at least 0.3 C (0.5 F) below the setpoint temperature
- operates on a duty cycle of 60% when the solution temperature is between at least 0.17 C (0.3 F) and 0.3 C (0.5 F) below the setpoint temperature
- operates on a duty cycle of 40% when the solution temperature is between at least 0.06 C (0.1 F) and 0.17 C (0.3 F) below the setpoint temperature
- operates on a duty cycle of 20% when the solution temperature is between the setpoint temperature and 0.06 C (0.1 F) below the setpoint temperature
- de-energizes when the solution temperature is greater than or equal to the setpoint temperature

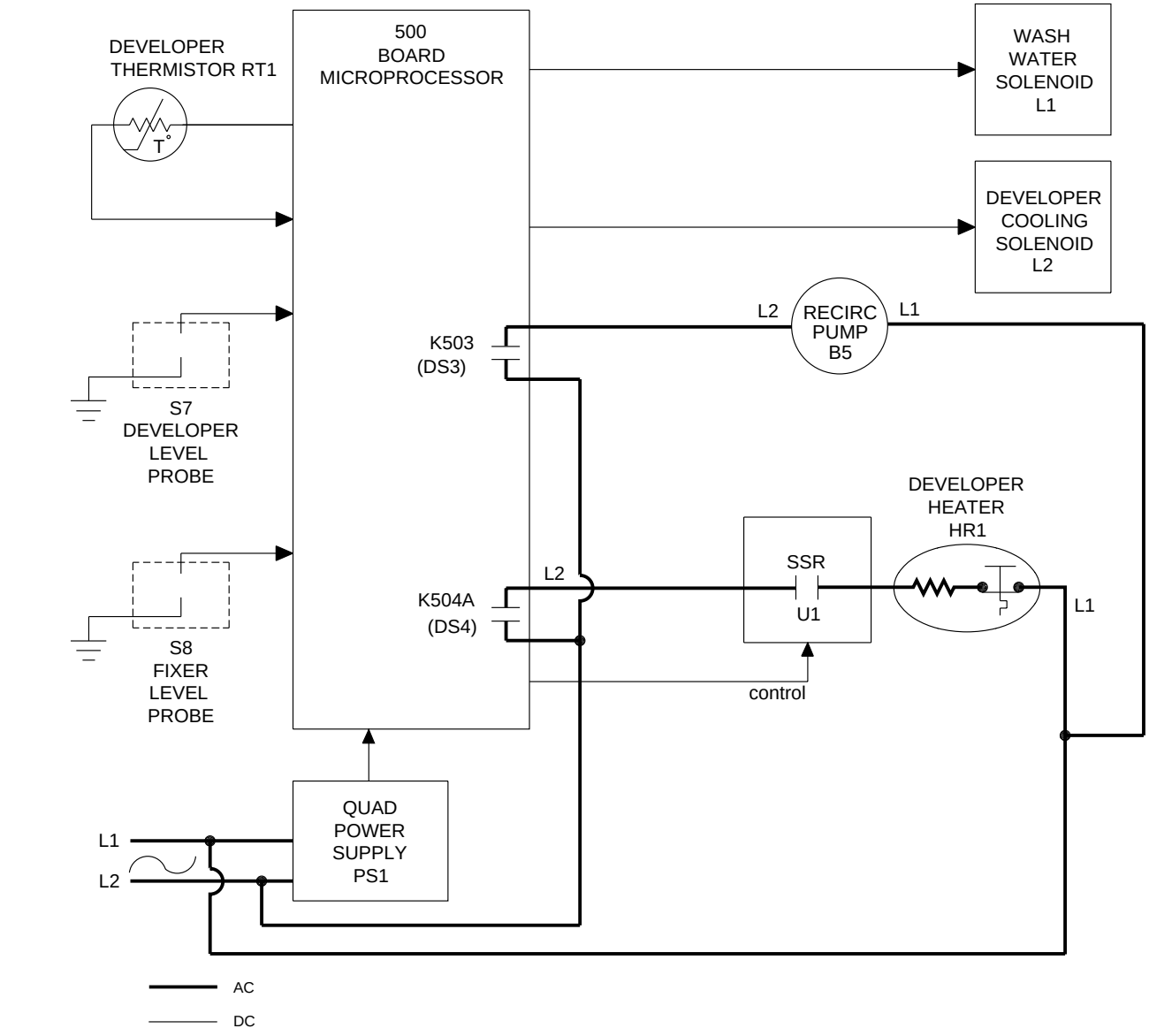
Developer Cooling

1. The cooling solenoid and the WASH WATER SOLENOID energize when the temperature of the developer exceeds the setpoint temperature by 0.17 C (0.3 F) for 5 seconds.
2. The PROCESSOR cools the developer solution by circulating it through the HEAT EXCHANGER in the WASH TANK.
3. The cooling cycle continues until the developer is sufficiently cooled.
4. The cooling solenoid and the WASH WATER SOLENOID de-energize (close), preventing the flow of developer solution through the heat exchanger.

Developer Temperature Display

The MICROPROCESSOR calculates the developer temperature by averaging 10 consecutive readings and updates the value on the ML300 PLUS display panel approximately every 10 seconds.

Figure 3 **Control Circuit for Developer Temperature**



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1. Correct levels of solution in each of the TANKS for developer and fixer immerse the LEVEL PROBES, providing separate paths to ground.
2. The MICROPROCESSOR detects the decreased resistance of the immersed LEVEL PROBES and actuates the RELAYS K503, K504A and K504B.
3. The RELAY K504A enables the DEVELOPER HEATER HR1. The LED DS4 illuminates when the RELAY K504A enables HR1.
4. The RELAY K503 energizes the recirculation pump B5. The LED DS3 illuminates when the RELAY K503 energizes B5.
5. The control signal from the 500 BOARD energizes the SOLID STATE RELAY SSR-U1, which energizes the DEVELOPER HEATER HR1. This HEATER operates as necessary to maintain the setpoint temperature of the developer solution.
6. An ANALOG to DIGITAL (A/D) CONVERTER on the 500 BOARD converts the analog resistance of the THERMISTOR to digital data.

7. The MICROPROCESSOR applies an algorithm that converts the digital data to temperature. Every one second, the MICROPROCESSOR compares this temperature to a setpoint temperature and determines if the solution requires either heating or cooling.
8. If the temperature of the developer solution is
   - below the setpoint, the microprocessor applies DC voltage at the correct duty cycle to control the RELAY SSR-U1, energizing the developer heater at the correct duty cycle. The duty cycle depends on the difference between the temperature of the developer solution and the setpoint temperature.
   - above the setpoint, the microprocessor de-energizes the developer heater and opens the WASH WATER solenoid (if it is not already open) and the DEVELOPER cooling solenoid. The DEVELOPER cooling solenoid allows developer to flow through the heat exchanger, cooling the developer.

Temperature Control Errors

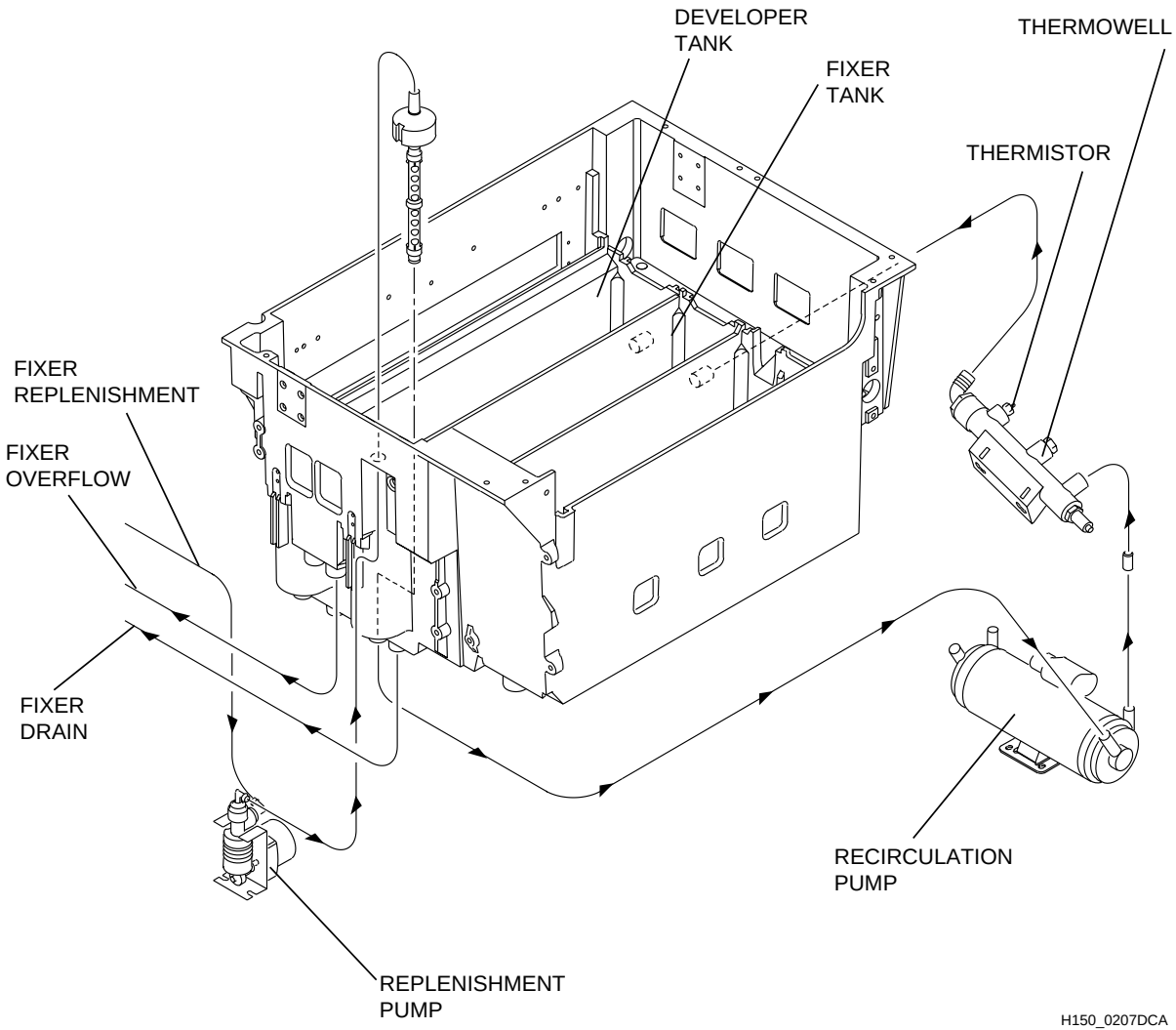
- Unable to Determine Developer Temperature (E034) If the thermistor is opened or shorted, or if the temperature control A/D converter is not operating correctly, an E034 will be displayed (if it is the highest priority). This error cannot be cleared unless the Processor is deenergized and then energized again. For more information about this condition, see Section 8: Thermistor and Temperature Measuring, Page 30.
- **Loss of Developer Heating Ability (E037) and Loss of Developer Cooling Ability (E038)** The rate at which the developer solution is heated and cooled is checked. If the rate is not correct, the appropriate error code will be displayed (if this error is the highest priority). These errors are cleared when either the rate corrects itself or the setpoint temperature is reached.
- The cooling rate is checked as long as cooling is needed. The heat rate is checked only when:
  - the developer heater is on full
  - the temperature of the solution is above 29 C (84 F)
  - the replenishment pumps are not on

Note

- minimum heating rate = an increase of 1.1 C (2.0 F) every 2 minutes
- minimum cooling rate = a decrease of 0.05 C (0.1 F) every 6 minutes

Fixer

Recirculation



The transport drive moves the film from the DEVELOPER TANK through a CROSSOVER into the FIXER TANK. The fixer solution removes unused silver halide from the film, stopping unnecessary further development of the visible image and increasing the permanency of the visible image. Like the DEVELOPER TANK, the fixer tank can be filled and replenished automatically from an external container of fixer solution. For more information about the replenishment cycle, see Page 25.

Recirculation takes place only when the tanks for both the developer and fixer are full. A LEVEL PROBE in each tank monitors the level of solution. The PROCESSOR has a DUAL-HEADED PUMP, which consists of a MOTOR that is magnetically coupled to the DEVELOPER RECIRCULATION PUMP and the FIXER RECIRCULATION PUMP. The MOTOR drives both PUMPS. The FIXER recirculation pump circulates the fixer solution through a thermowell and the FIXER TANK. When necessary, the FIXER HEATER Hr2 in the THERMOWelL heats the solution.

Note

The control circuit for the recirculation of the fixer is the same as the control circuit for recirculation of the developer; See Page 12.

Fixer Temperature

The fixer must be heated to a minimum specified temperature to ensure optimum processing of the film.

The THERMOWELL contains a thermistor. The resistance of the THERMISTOR changes inversely with the temperature of the fixer solution. For more information about the control circuit of the thermistor, see Page 30.

Fixer Heating

The fixer heater operates at full capacity when the fixer temperature is below the setpoint temperature. When the temperature is above the setpoint, the HEATER de-energizes.

The fixer solution should reach the setpoint temperature within approximately 20 minutes after the PROCESSOR is energized.

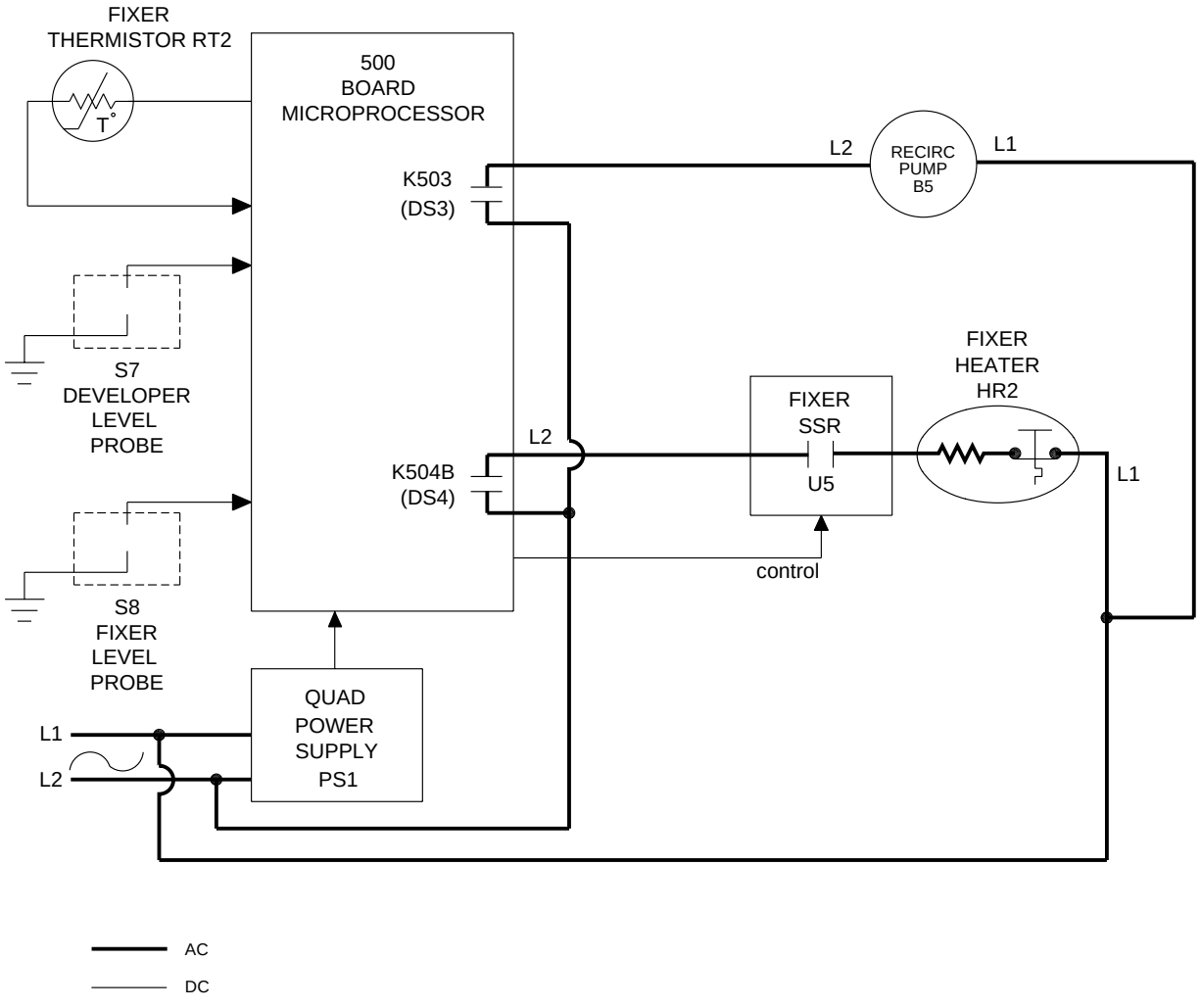
Fixer Cooling

The fixer operates effectively at higher temperatures and does not have to be cooled.

Fixer Temperature Display

The fixer temperature reading is available on the ML300 PLUS DISPLAY PANEL.

Figure 4 **Control Circuit for Fixer Temperature**



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The control circuits for the fixer and developer are similar, except that the fixer does not include a cooling circuit. Both circuits use the RelayS K503 and K504.

1. Correct levels of solution in each of the TANKS for developer and fixer immerse the LEVEL PROBES, providing separate paths to ground.
2. The MICROPROCESSOR detects the decreased resistance of the immersed LEVEL PROBES and actuates the RELAYS K503, K504B and K504A.
3. The RELAY K504B enables the FIXER HEATER HR2.The LED DS4 illuminates when the RELAY K504B enables HR2.
4. The RELAY K503 energizes the recirculation pump B5. The LED DS3 illuminates when the RELAY K003 energizes B5.
5. The control signal from the 500 BOARD energizes the SOLID STATE RELAY SSR-U5, which energizes the FIXER HEATER HR2. This HEATER operates as necessary to maintain the setpoint temperature of the fixer solution.
6. An A/D CONVERTER on the 500 BOARD converts the analog resistance of the THERMISTOR to digital data.
7. The MICROPROCESSOR applies a software algorithm that converts the digital data to temperature. The MICROPROCESSOR continuously compares this temperature to a setpoint temperature and determines if the solution requires heating.
8. When the temperature is below the setpoint temperature, the MICROPROCESSOR applies a DC voltage to SSR-U5, energizing the fixer heater.

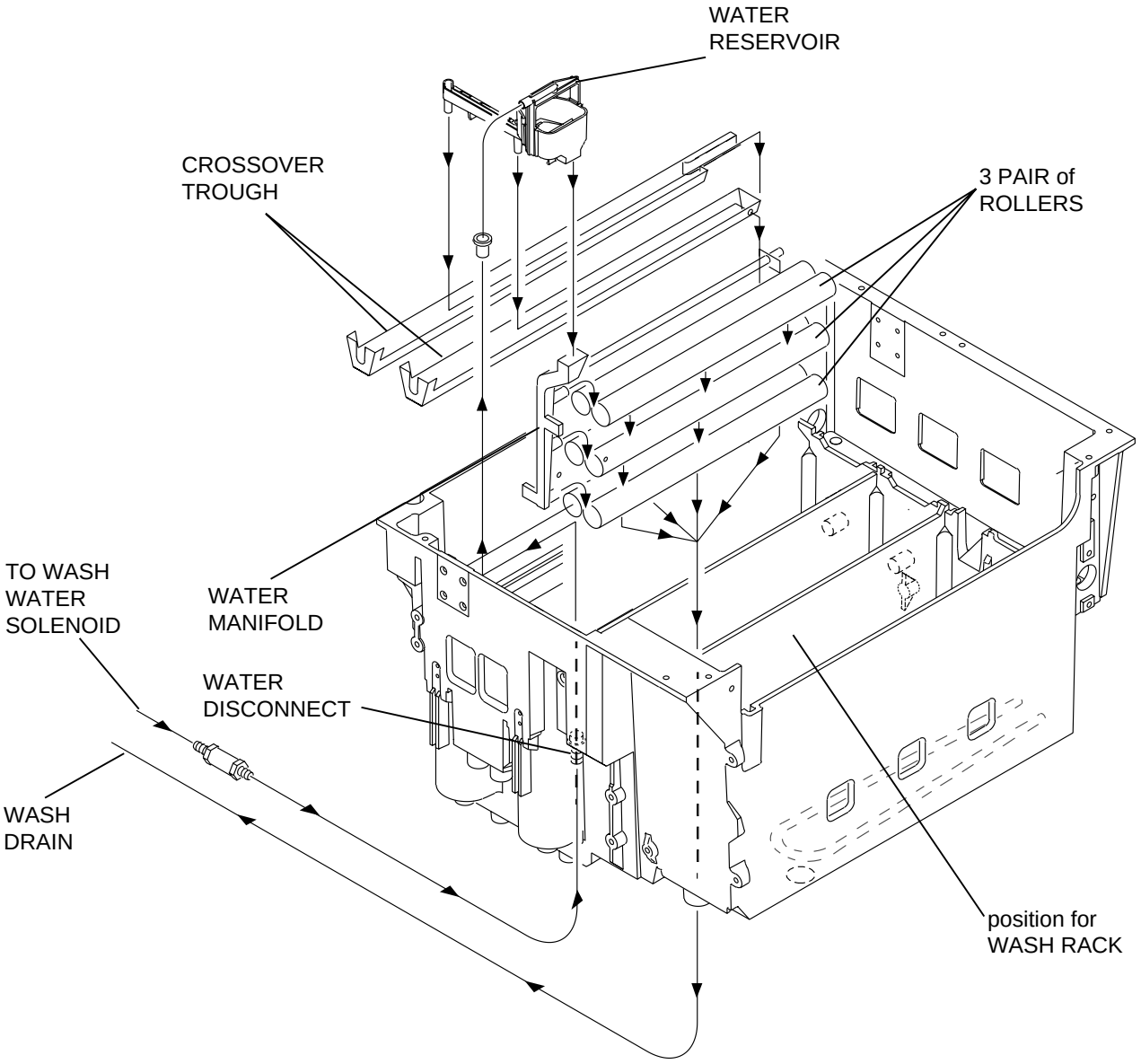
Fixer Control Errors

The temperature control function checks for the following errors:

- Unable to Determine Fixer Temperature (E035) If the thermistor is not working correctly, an E035 will be displayed (if it is the highest priority). This error cannot be cleared unless the Processor is deenergized and then energized again. For more information about this condition, see the thermistor control section on page 30.
- Loss of Fixer Heating Ability (E039) This is the rate at which the fixer solution is heated is checked. The minimum acceptable heating rate is an increase of 1.2 C (2.0 F) every 2 minutes. If the rate is not correct, an E039 is displayed (if it is the highest priority). This error is cleared when either the rate corrects itself or the setpoint temperature is reached. The heat rate error is only checked when:
  - the fixer heater is on full
  - the temperature of the solution is above 29 C (84 F)
  - the replenishment pumps are not on

Wash

System



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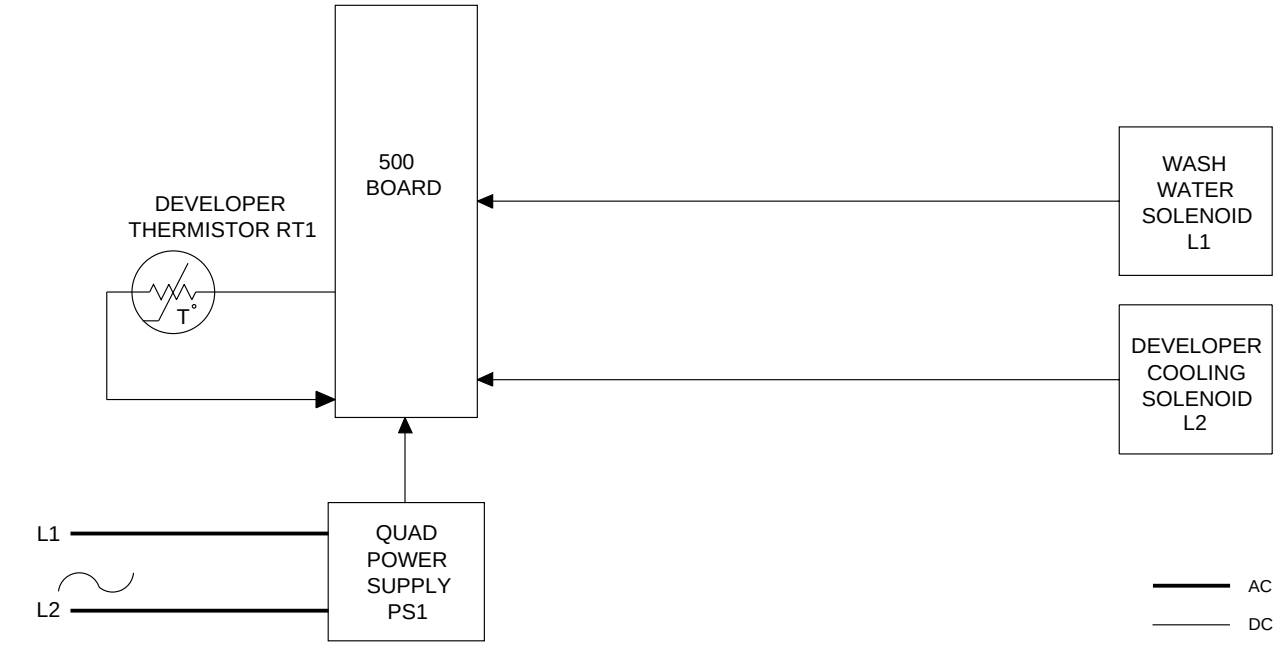
H150_0208DC

Excess solutions remaining on the film can cause artifacts on the film during the drying process and reduce the permanency of the image. The wash RACK supplies fresh water that removes all excess developer and fixer solutions from the film.

The customer's external water supply provides water to the WASH RACK. The temperature of the water must be 4 - 32 C (40 - 90 F) and at least 5.5 C (10 F) below the operating setpoint of the developer temperature. The water flows through a 50-micron filter, which the customer supplies, to a connection at the back of the PROCESSOR.

Figure 5 **Control Circuit for Wash Water**



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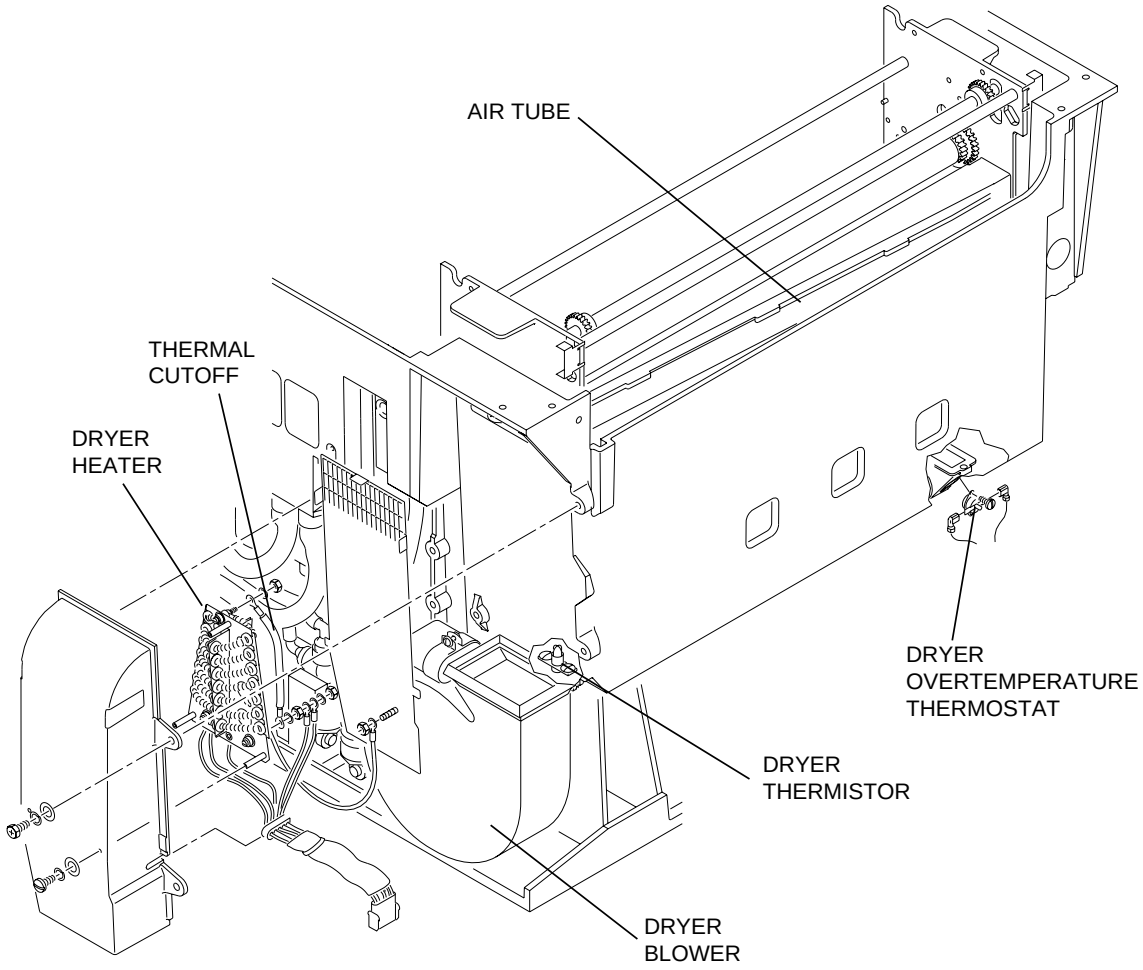
The WASH WATER SOLENOID

- opens when the leading edge of the film exits the FIXER RACK to allow water to flow at a rate of 1.9 L (0.5 gal) 15% per minute into the PROCESSOR
- closes approximately 15 seconds after the film exits the WASH RACK, if no additional films enter the PROCESSOR and cooling of the developer is not required.
- opens to allow flow of water onto the HEAT EXCHANGER to cool the developer as necessary

From the WASH WATER SOLENOID, the water flows through the FLOW CONTROL VALVE and the WATER DISCONNECT to the WATER RESERVOIR. This RESERVOIR distributes water to the CROSSOVER TROUGHS and to the WATER MANIFOLD. The CROSSOVER TROUGHS allow water to wet the CROSSOVER ROLLERS, reducing chemical deposits. The WATER MANIFOLD distributes the water to the 3 pair of ROLLERS in the WASH RACK to wash the film.

Dryer

System



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H150_0155DA

The film exits the wash RACK and passes through the squeegee ROLLERS, which spread remaining drops of water across the film surface to minimize water spots.

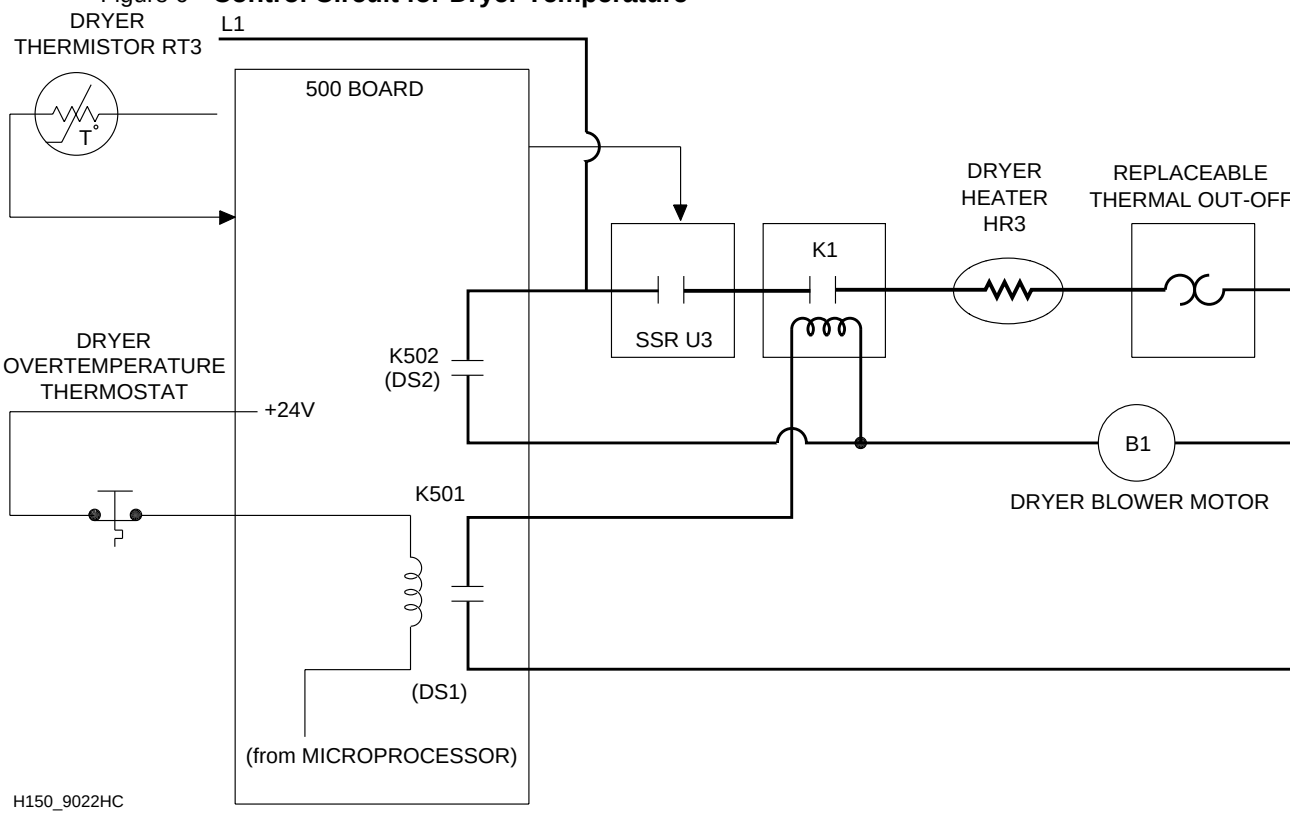
The DRYER BLOWER forces hot air through the air tubes, which circulate the air across both sides of the film as it moves through the DRYER. The DRYER heater heats the air to a temperature of 21 - 65.5 C (70 - 150 F). The temperature of the DRYER can be adjusted in increments of either 1 C or 1 F on the ML300 PLUS display panel.

If the temperature is greater than 76.7 C (170 F) near the bottom of the DRYER RACK, the OVERTEMPERATURE THERMOSTAT opens, de-energizing the DRYER HEATER. The THERMOSTAT automatically resets when the temperature decreases to 54.4 C (130 F). If the temperature is more than approximately 167 C (333 F) in the PLENUM, the THERMAL CUTOFF opens, de-energizing the DRYER HEATER. If the THERMAL CUTOFF opens, a service representative must install a replacement.

The ML300 PLUS DISPLAY PANEL indicates the setpoint temperature for the dryer.

Dryer Temperature

Figure 6 **Control Circuit for Dryer Temperature**



When the ML 300 PLUS detects film:

1. The relay K502 energizes the dryer blower motor B1. The LED DS2 illuminates when the 500 BOARD energizes K502.
2. The RELAY K501 energizes the RELAY K1, enabling the DRYER HEATER HR3. The LED DS1 illuminates when the 500 BOARD energizes K501.
3. The microprocessor applies a software algorithm that converts the resistance of the DRYER thermistor RT3 to temperature. The MICROPROCESSOR continuously compares this temperature to the setpoint temperature.
4. When the temperature decreases below the setpoint temperature, the microprocessor sends a DC signal to the SOLID STATE RELAY SSR-U3, energizing the DRYER HEATER HR3. To prevent damage to the DRYER heater, the DRYER HEATER energizes 3 seconds after the MICROPROCESSOR energizes the DRYER BLOWER.

The DRYER heater operates at a duty cycle:

Actual Temperature from RT3	Duty Cycle
More than 0.6 C (1 F) below the setpoint	100%
Between the setpoint and 0.6 C (1 F) below the setpoint	85%
At the setpoint	0%
Between the setpoint and 0.6 C (1 F) above the setpoint	20%
More than 0.6 C (1 F) above the setpoint	0%

Temperature Control Errors

The temperature control function checks for the following errors:

Dryer Overtemp Data Error (E002)

If the dryer temperature exceeds the maxiumum value of the A/D converter (approximately 74 C or 165 F), an overtemperature condition exists. The error E002 will be displayed, and the Processor will shutdown after the last film exits.

Dryer Overtemperature Thermostat (E005)

An error E005 will be displayed if

- the dryer temperature exceeds approximately 76.7 C (170 F) and the overtemperature thermostat opens.

Unable to Determine Dryer Temperature (E036)

If the thermistor is not working correctly, an E036 will be displayed (if it is the highest priority error). This error cannot be cleared unless the Processor is deenergized and then energized again. For more information about this condition, see the thermistor control section on Page 30.

Inoperative Dryer Error (E040)

The rate at which the air in the dryer is heated is checked. The minimum acceptable heating rate is an increase of 0.28 C (0.5 F) every 2 minutes. If the rate is not correct, the error E040 will be displayed (if it is the highest priority error).

The heat rate error is only checked when:

- the dryer heater is operating
- film is not present in the Processor
- after initialization is completed at power-up

Dryer Under Setpoint Temperature Warning (E134)

If the dryer setpoint temperature is changed to a higher value, this error will be displayed until the new setpoint is reached

Section 5: Replenishment

Overview

During film processing, the film absorbs developer and fixer solutions. The operator must add new chemicals periodically to maintain an effective level of chemical activity. The MICROPROCESSOR monitors film usage and uses an algorithm to automatically replenish these solutions from an external source or an AUTOMIXER. This algorithm determines when to energize the replenishment pumps for both developer and fixer solutions. Using the DISPLAY PANEL, the operator can change the amount of replenishment added during each replenishment cycle. The new solutions are pumped directly into the TANKS for the developer and fixer and enter the recirculation system.

The replenishment pumps can be disabled to allow maintenance of the PROCESSOR. The operator can disable the replenishment pumps using one of 2 methods:

1. **Pulling the processor out from the ML300** PLUS disables the Replenishment pumps and displays the error code E128 (Processor not in place).
2. **Selecting "Pump Disable"** at the DISPLAY PANEL disables the replenishment pumps and displays the error code E130 (Replenishment Pumps Disabled).

The PROCESSOR provides 2 modes of replenishment: Automatic and Flooded. The operator can select either mode at the DISPLAY PANEL.

Replenishment Modes

Calculation of Replenishment

The software calculates the length of time that the PUMPS should be energized by dividing the *replenishment volume*, which is stored in memory, by the *replenishment flow rate*.

Automatic

The Automatic Replenishment mode is standard and occurs under 2 conditions:

- High Film Usage occurs when the PROCESSOR is energized for 24 hours and processes more than 75 sheets of film in that 24 hours. The software algorithm starts the replenishment cycle each time the PROCESSOR processes approximately 1500 cm^2 (238 $in.^2$) of film. This area is equal to one 35 x 43 cm (14 x 17 in.) sheet of film. The operator can adjust, within the range of 20 mL to 500 mL, the volume of replenishment that is added for each 1500 cm^2 (238 $in.^2$) of processed film. The default volumes are 60 mL of developer and 85 mL of fixer.
- Low Film Usage occurs when the PROCESSOR processes less than 75 sheets of film within 24 hours. During that time, the PROCESSOR must be energized either for the full 24 hours or twice, the second time for more than 3.5 hours. In either application, the different replenishment volumes depend on the number of films processed. The replenishment pumps automatically energize every half hour during a 4-hour period:

Film Count	Replenishment Added during 4 Hours
less than 55	1 liter (125 mL / ½ hour)
55 - 65	750 mL (93 mL / ½ hour)
66 - 74	400 mL (50 mL / ½ hour)

Flooded

The PROCESSOR uses the flooded replenishment mode in very low-volume applications: 25 or less sheets of 35 x 43 cm (14 x 17 in.) film (or equivalent film area) processed in 24 hours. In this mode replenishment occurs every 5 minutes of operation and after 1500 cm^2 (238 $in.^2$) of film has been processed. The software determines the amount of replenishment. The operator can modify this amount, within the range of 20 mL to 200 mL.

Filling the TANKS for the Developer and Fixer:

During Initialization or Normal Operation

If the solution level in the PROCESSOR is low during initialization or normal operation, the corresponding replenishment pump energizes.

Tank-Fill Mode

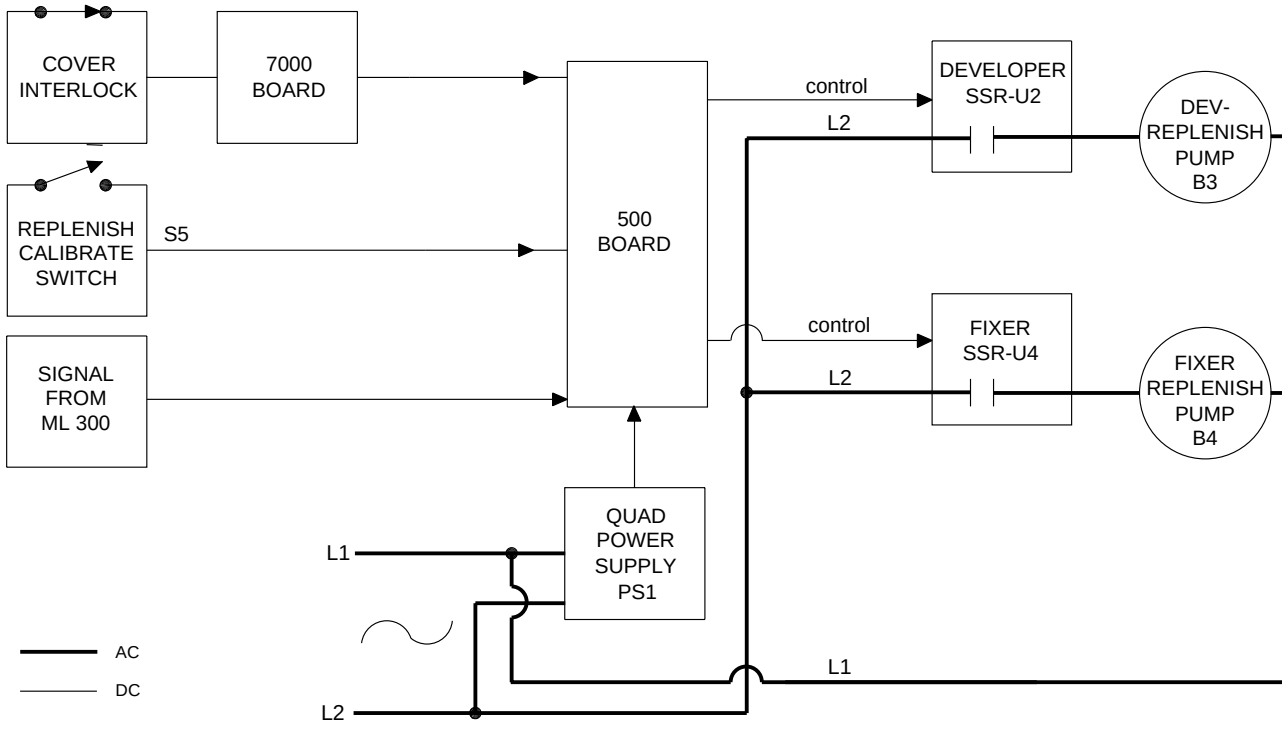
At installation or after periodic maintenance, select this mode at the DISPLAY PANEL to fill an empty TANK. This mode de-energizes the DRYER heater, DRYER blower, and drive motor. The DISPLAY PANEL displays the error code E129 (Tanks Currently Being Filled).

When the level PROBES detect a correct solution level in the DEVELOPER and FIXER TANKS, the MICROPROCESSOR disables the “Tank Fill Mode,” activates the reCIRCULATION pump, enables the heater, blower, and drive motor. The DISPLAY PANEL removes the error code.

Replenishment Errors

When the developer or fixer solutions do not reach the correct level within the allowed time limit, the error code E032 (Developer Tank Fill) or E033 (Fixer Tank Fill) occurs, and the MICROPROCESSOR de-energizes the pumps. The allowed time limits are 4 minutes during initialization or normal operation and 15 minutes if the PROCESSOR is in the “Tank-Fill Mode.”

Control Circuit for Replenishment



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With S4 closed, any of the following actions causes the MICROPROCESSOR to actuate this circuit:

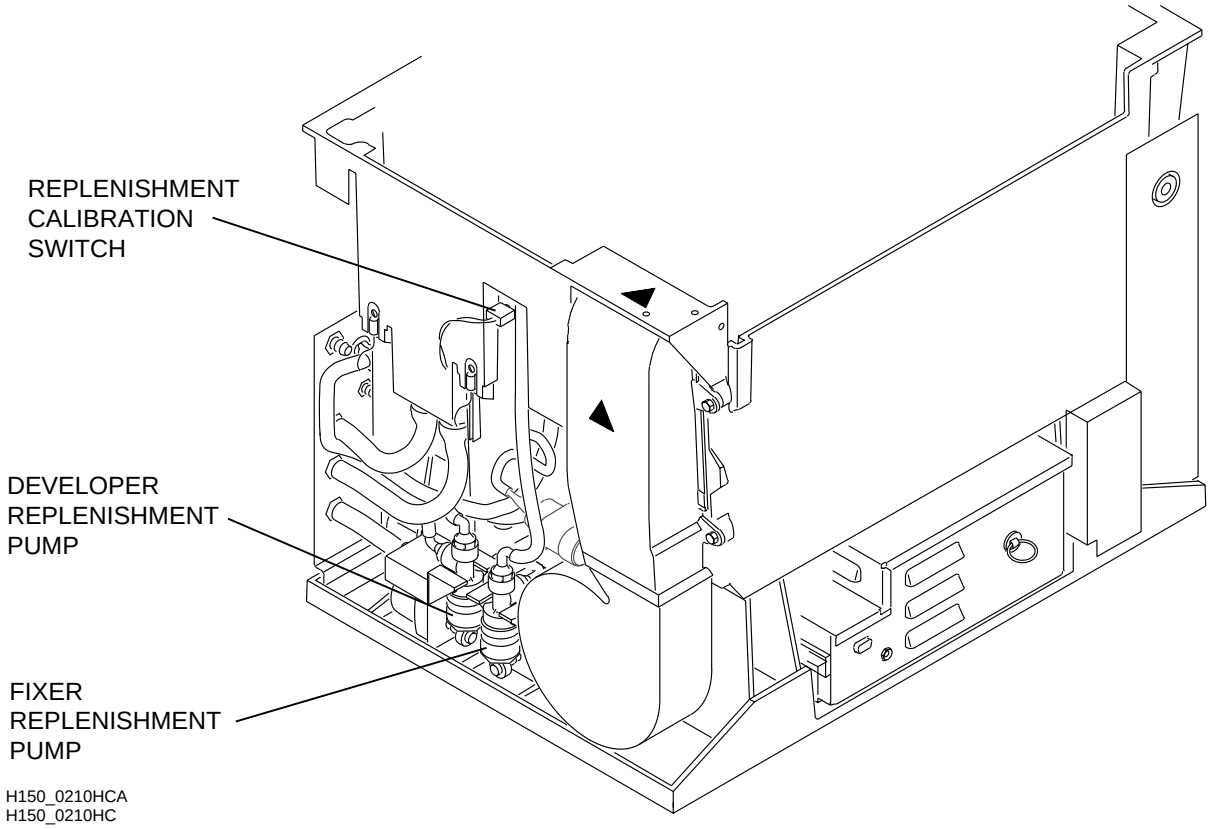
- When the operator first energizes the PROCESSOR.
- In the AUTOMATIC or FLooded replenishment Modes, when the ML300 PLUS detects 0.15 m2 (238 in2) of film.
- If the operator selected either “Tank Fill” or “Calibration” at the ML300 PLUS Display Board, the microprocessor actuates the circuit when necessary.
- If the operator presses and holds the “Calibration Switch” for greater than 5 seconds.

- Every 5 minutes during Flooded Replenishment Mode and as necessary during Low Film Usage in the Automatic Replenishment Mode.
- When the LEVEL PROBES detect low levels of solutions.

To actuate the replenishment circuit, the microprocessor sends DC voltage to SSR-U2 or SSR-U4 or both of these RELAYS, which then provide AC voltage to the replenishment pumps.

When replenishment is complete, the MICROPROCESSOR removes the DC voltage from the solid state relays, de-energizing the PUMPS.

Calibration



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The operator enables the calibration procedure for the appropriate PUMP, using the menus displayed at the display panel. See the procedure for “Calibration” in the Operator's Manual.

- The operator activates the REPLENISHMENT CALIBRATION SWITCH.
- The MICROPROCESSOR energizes the REPLENISHMENT PUMP for a fixed amount of time, approximately 5 seconds, dispensing a volume of solution.
- The operator measures the volume (mL) of solution and enters that measurement at the ML300 PLUS DISPLAY PANEL.
- The MICROPROCESSOR calculates the correct volume rate (mL/second) from the measured volume and the and the corresponding operating time of the REPLENISHMENT PUMP.

Note

The volume measured during the calibration procedure is not the same as the replenishment volume added to the TANK for a 14 x 17 in. (or equivalent area) film.

Replenishment Verification: With the TOP COVER up, the operator presses and holds the replenishment calibration switch for 5 seconds to energize both pumps. The PUMPS dispense a volume specified for a 1535 cm^2 (238 $in.^2$) of film.

Section 6: Standby Mode

The Standby Mode provides conservation of energy and at the same time the capability to quickly begin processing film. If no new film enters the ML300 PLUS, the PROCESSOR will enter the Standby Mode approximately 15 seconds after the last film has exited. Based on the transport speed and length of the film path, the software determines when the last film exited the PROCESSOR. When the PROCESSOR enters the Standby Mode, the MICROPROCESSOR:

- closes the WASH WATER SOLENOID, unless water is needed for developer cooling and for wetting the ROLLERS.
- maintains the developer and fixer temperatures
- maintains the temperature in the DRYER RACK
    1. de-energizes the dryer BLOWER and the DRYER HEATER for 4 minutes
    2. energizes the DRYER BLOWER and reads the temperature of the air in the DRYER RACK
    3. energizes the DRYER HEATER if the temperature in the DRYER is below the setpoint temperature
    4. de-energizes for 4 minutes both the DRYER BLOWER and DRYER HEATER when the temperature in the DRYER equals the setpoint temperature
- operates the transport drive, depending on which of the 2 Standby Modes the customer selects: continuous or interval.

In the “Continuous Standby Mode” the transport drive remains energized, operating at a low speed 53.3 cm/minute (21 in./minute) after the film exits the PROCESSOR.

In the “Interval Standby Mode” the PROCESSOR operates in cycles of 90-second intervals followed by 8-minute intervals. At the beginning of each 90-second interval:

- The 90-second timer on the MICROPROCESSOR begins.
- The TRANSPORT DRIVE operates at the setpoint speed.
- The WASH WATER SOLENOID opens every 4th cycle, wetting the ROLLERS.

At the beginning of each 8-minute interval:

- The 90-second timer expires, and the 8-minute timer begins.
- The TRANSPORT DRIVE de-energizes.
- The WASH WATER SOLENOID closes.

The PROCESSOR automatically enters the operating mode when the ML300 PLUS detects film.

Section 7: Sleep Mode

The “Sleep Mode” allows the customer to disable most of the PROCESSOR, conserving energy. The operator selects the “Sleep Mode” at the ML300 PLUS DISPLAY PANEL.. Also, the operator can program the PROCESSOR to automatically energize at a selected time. The ML300 PLUS DISPLAY PANEL displays the time at which the PROCESSOR will exit the Sleep Mode.

If the operator does not program the PROCESSOR to automatically energize at a selected time, the DISPLAY PANEL displays the message “Processor in Sleep Mode.”

When the PROCESSOR enters the Sleep Mode, the MICROPROCESSOR

- de-energizes all HEATERS and the RECIRCULATION PUMPS
- disables all LEVEL PROBES
- monitors the SLEEP SWITCH
- monitors the TIMER
- displays at the DISPLAY PANEL the “wake-up” time if the operator set the TIMER
- executes the optional “ROLLER Jog” or optional “Cool Down” (if selected)

The operator can select 2 options for the “Sleep Mode”: “ROLLER Jog” option and “Cool Down” option. The “ROLLER Jog” option drives the transport drive periodically to prevent chemicals from accumulating on the ROLLERS. The “Cool Down” option energizes the DRYER BLOWER to cool the solutions slowly, preventing condensation. The following table describes the operations that occur for different combinations of these 2 options.

“Cool Down” On “Roller Jog” On	Cool Down Phase: • The DRYER BLOWER operates for 3 hours. • The transport drive stops operating and the WASH WATER SOLENOID closes for 10 min. • The transport drive operates and the WASH WATER SOLENOID opens for 90 sec. • The DEVELOPER COOLING SOLENOID opens. • The RECIRCULATION PUMPS operate when the transport drive operates and the solution levels are not low.
	Dormant Phase: At the end of 3 hours • The DRYER BLOWER de-energizes. • The transport drive and the WASH WATER SOLENOID operate in cycles: 30 minutes off, 90 seconds on.
“Cool Down” Off “Roller Jog” On	Same as Dormant Phase above.
“Cool Down” On “Roller Jog” Off	Cool Down Phase: Same as Cool Down Phase above.
	Dormant Phase: At end of 3 hours • The DRYER BLOWER does not operate. • The transport drive does not operate.
“Cool Down” Off “Roller Jog” Off	• The DRYER BLOWER does not operate. • The transport drive and the WASH WATER SOLENOID do not operate.

Section 8: Thermistors and Temperature Measuring

The temperature of the solutions and the dryer is determined on the microprocessor 500 circuit board by performing an analog to digital (A/D) conversion on the resistance of the thermistor. This data is then converted to a temperature by means of a software algorithm.

The Processor checks for 2 different malfunctions with the temperature circuit: wrong A/D temperature conversions and faulty thermistors. If one of these malfunctions occurs, the Processor will display one of the following errors:

- E034 Unable to determine developer temperature
- E035 Unable to determine fixer temperature
- E036 Unable to determine dryer temperature

The A/D temperature conversions are checked by reading a precision resistor on the 500 circuit board (instead of the thermistor) every 3/4 second. If the A/D reads the precision resistor incorrectly for 5 consecutive readings, the A/D is considered to be inoperative.

If the A/D reading of the thermistors is outside of the allowed range for 5 consecutive readings, the thermistor is considered to be inoperative.

These checks are not performed until 5 1/2 minutes after power-up. This delay prevents open thermistor errors due to cold solution temperatures brought on by a cold room ambient temperature.

Section 9: Power Distribution and Control

AC Distribution

The Processor runs on single-phase or 3-phase 200 - 240 V AC, 50 or 60 Hz.

The Processor uses AC power to operate all motors, except the drive motor, which uses 24 V DC. AC power also supplies the quad power supply, which converts the power into 4 DC voltages.

When the power enters the Processor, it is directed to a transformer. The transformer increases or decreases the incoming voltage and distributes the power to the components.

DC Distribution

The quad power supply supplies the DC voltages used in the Processor. It converts the incoming AC voltage into +5, +12, -12, and +24 V DC. This voltage is distributed to the following components:

- **500 Circuit Board**
- **Drive Motor (+24 V DC)**
- **Solid State Relays (+5 V DC)**
- The 500 circuit board switches 5 volts on or off to control 5 solid state relays. The solid state relays energize the following components:

  SSR-U1 - developer heater

  SSR-U2 - developer replenishment pump

  SSR-U3 - dryer heater

  SSR-U4 - fixer replenishment pump

  SSR-U5 - fixer heater

- **Electromechanical Relays (+24 V DC)**
- The 500 circuit board switches 24 volts on or off to control 6 electromechanical relays. The relays energize the following components:

  K501 - dryer heater enable

  K502 - dryer blower enable

  K503 - recirculation pump

  K504 - developer and fixer heaters enable

Note

The Processor uses the electromechanical relays mainly as enable relays and the solid state relays as control relays. For example, the developer heater is enabled by K504, but SSR-U1 actually controls the developer temperature.

Section 10: Publication History

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